DOCUMENT RESUME

ED 448 059 SE 064 359

AUTHOR	Whitman, John D.; Gaffney, Dennis
TITLE	Secrets of Lost Empires: Family Activity Book.
INSTITUTION	WGBH-TV, Boston, MA.
SPONS AGENCY	Corporation for Public Broadcasting, Washington, DC.
PUB DATE	2000-00-00
NOTE	37p.; Additional funding provided by the David H. Koch Charitable Foundation.
AVAILABLE FROM	WGBH, 125 Western Avenue, Boston, MA 02134. E-mail: wgbh materials request@wgbh.org.
PUB TYPE	Guides - Classroom - Teacher (052)
EDRS PRICE	MF01/PC02 Plus Postage.
DESCRIPTORS	Elementary Secondary Education; Foreign Countries; *Hands on Science; *Science Activities; Science Instruction
IDENTIFIERS	Egypt; NOVA (Television Series)

ABSTRACT

This family activity book features information on the background and filming of five stories. "Pharaoh's Obelisk" questions how ancient Egyptians transported and raised stone obelisks. "Roman Bath" studies how Romans built bathhouses and attempts to build a working Roman bath. "China Bridge" investigates the structure of the China Bridge and recreates the bridge. "Medieval Siege" builds two possible designs of missiles called Warwolfs, which were built for King Edward I of England. "Easter Island" explores the huge stone statues on the island and tries to build one. (YDS)

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Family Activity Bo

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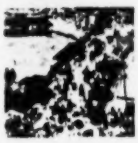

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About NOVA's *Secrets of Lost Empires*

Giant stone monuments. Paintings of delicate wooden bridges. Ruins of ancient buildings with running water and heating systems. All over the world, traces of once-powerful civilizations remain behind, causing us to wonder about the people who created them. These mysterious builders had no power tools; no computers; no cranes, trucks, bulldozers, or other modern construction equipment. Yet they built structures that still amaze us today.

"How did they do it?" asked the filmmakers at NOVA. To answer this question, NOVA organized expert teams of engineers, archaeologists, historians, and master builders. Each team traveled to the land of a mighty empire to try to recreate its magnificent structures. The teams' challenge was to use the same materials, tools, and techniques as the original builders. Guided by clues found in ruins, paintings, and texts, the teams developed and tested their hypotheses. Sometimes they worked; sometimes they didn't. The groups made adjustments and tried again, each attempt revealing something about the structures' secrets.

The stories in this book are based on the hypotheses and findings of the NOVA teams. Reading the stories will also give you a sense of what it might have been like to live in each of the five civilizations. Then explore the structures yourself by trying the hands-on activities that follow each story.

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Secrets of Lost Empires
A five-part mini-series from NOVA

Pharaoh's Obelisk
How did the ancient Egyptians transport and raise stone obelisks that weighed as much as 400 tons (360 metric tonnes)? NOVA's experts try dragging gigantic stones, loading an obelisk onto a boat for a trip down the Nile, and raising a massive monolith in the desert.

ROMAN BATH
The Romans built bathhouses with vaulted and domed roofs, waterproof concrete, and elaborate plumbing and heating systems. The NOVA team attempts to build a working Roman bath, with the goal of taking a dip themselves.

CHINA BRIDGE
A famous scroll from the twelfth century depicts a graceful wooden bridge curved like a rainbow above a river. Working from a painting, the team tries to recreate the bridge over a canal.

Medieval Siege
Written records tell of a fearsome missile-throwing weapon called "Warwolf," built for King Edward I of England. NOVA's experts build two possible designs of the machine and test them on a model castle wall.

EASTER ISLAND
This remote island is dotted with huge stone statues. What do they represent? How were they moved around the island? NOVA makes a new statue and tries to move and raise it onto a platform.

A Behind-the-Scenes Look at the Making of *Pharaoh's Obelisk*

Rick Brown, a sculptor and teacher at the Massachusetts College of Art, tells the story of his family's role in NOVA's 1999 attempt to raise an obelisk.

Rick and Laura Brown

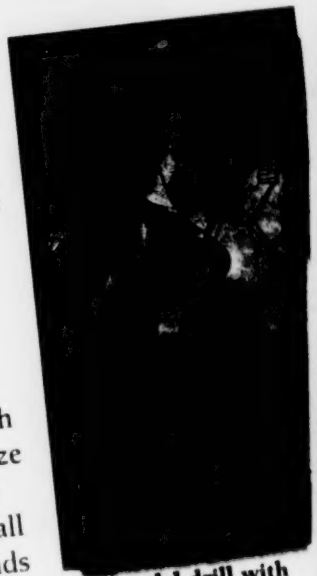
January 10, 1999
I get a phone call from NOVA. They want me to make reproductions of ancient Egyptian tools for their obelisk film. What a great project! Instead of being paid, I ask to go along to help with the film in Egypt.

January 13
NOVA agrees! I'm thrilled. That's the way the world works: A door opens, and you run through it.

January 16
My wife Laura and I visit museums to investigate ancient Egyptian tools. Since she is a housebuilder and I am a sculptor, we have a passion for tools. We know the Egyptians used copper and bronze drills, but wonder how these soft metals could have cut hard granite. After our trip to the museums and much reading, my hypothesis: Granite is too hard—they must have used drills with very hard, jeweled tips.

January 25
I tell NOVA that my son Wyly, who worked on their trebuchet project in Scotland, would be a huge help in Egypt. NOVA agrees to take him, too.

Early February
Laura, Wyly, and I take a picture of a drawing from an Egyptian tomb that shows a worker holding a drill. We enlarge the drawing to life size using a copy machine. Then we create each part of the drill to match the enlarged drawing. We carve a large wooden shaft and handle, make stone weights held with leather straps, and cast bronze cylinders. The whole drill is about 3 feet [0.91 meters] tall and weighs about 150 pounds [68 kilograms]. Our students think it looks like a piece of modern sculpture.



The model drill with its inspiration

March 9
Pack bags with all kinds of tools: chisels, blades, mallets, drills. Wyly and I end up with "carry-on" bags each weighing more than 100 pounds [45 kilograms]!

March 13
Arrive in Aswan, Egypt. Ride in taxi on dirt road. Vendors sell goods in open stalls. Hustling, bustling everywhere. Machinery shops. Animals pulling carts. Children on their way to school. Buses, big trucks. Old world, new world.

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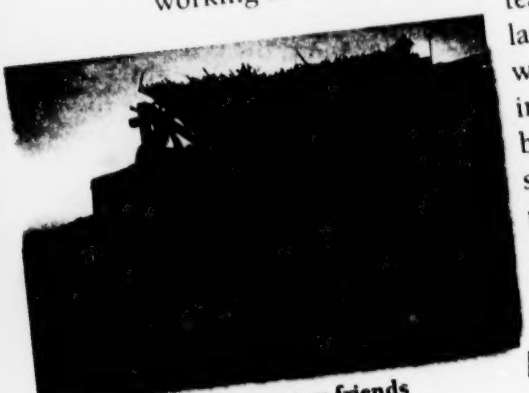
At the Aswan quarry, we find the crew trying to move a 25-ton [23 metric tonnes] block of granite. The block is lashed to a wooden sledge, which rests on timbers greased with lard. Workers use poles to push the sledge, while 170 people pull the ropes. The air is filled with dry dust and frustration. A rope breaks on the sharp corner of a rock. After much work, the stone is pulled only 20 feet [6.1 meters].

Mark Whitby, the chief engineer, asks Wyly and me to build a wooden structure that will be rigged with ropes to rotate the obelisk onto its pedestal. We stay up late designing the structure—we don't want it to break and spoil the project. We call a friend who is an engineering professor back in the United States. We ask him to calculate whether our design will be strong enough to rotate the obelisk. Using his calculator while we are on the phone, he assures us it will work.

March 14

We're making friends with the local workers on the project. They are helpful and hard-working and always smiling. They try to teach us Arabic, laughing when we say things incorrectly. They build a wooden shed with a grass roof to protect us from the hot sun.



The shed built by our new friends

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Julia Cort is a documentary producer at NOVA. She produced the film *Pharaoh's Obelisk*, which relates NOVA's second attempt to raise an obelisk using historical tools and techniques. She shared some stories about making the film.

Julia Cort, Mark Lehner, and their daughter Eliza in Egypt

How did you get involved in making this film?

Julia: I had worked on two other NOVA films in Egypt, one about reconstructing a pyramid and the other about the earlier attempt to raise an obelisk. The first obelisk film was very interesting, but it went over budget and took a long time to make—and in the end, we never did raise the obelisk. We were all very disappointed. So when Michael Barnes, the executive producer, asked me to do another obelisk film, I thought he was crazy at first. But then I started to think it would be good to have a second chance to raise an obelisk. After all, we had learned a lot from our first try.

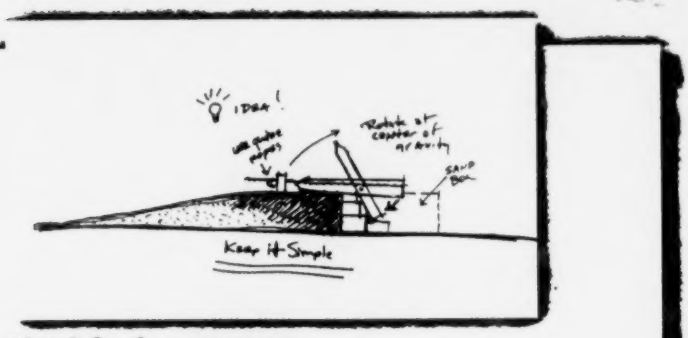
I also thought I'd get a chance to work with my husband [archaeologist Mark Lehner, a member of the expert team], whom I had actually met filming the pyramid show. I thought we'd have fun in Egypt with our daughter Eliza, who was 21 months old then.

What was it like to be in a place with such an ancient history?

Julia: It was fascinating. One day, we rowed across the Nile in a tiny, beat-up rowboat to Seheil Island. We saw granite boulders covered with graffiti thousands of years old. Everything was quiet except for the mooing of a cow and the bleating of goats. I felt like we were going back in time. On the riverbank we saw an elderly woman who was covered, as usual, in black from head to toe. It all seemed very ancient. Suddenly, we heard a familiar electronic ringing, and this little old lady whipped out her cell phone! In that instant, we were yanked back from 2500 B.C.E. to A.D. 1999.

Continued on page 5

The wooden rigging atop the obelisk



Sketch for the new strategy

The workers invite us to dinner. Can't go because I must work into the night with Wyly and others to figure out plan for obelisk rigging. But we like to work hard building things and solving problems. It's like jumping into a cold, rushing river—exciting but sometimes a little scary.

March 15

Denys Stocks, an expert in ancient tools, shows us how the Egyptians might have cut granite so cleanly. He pours sand into a groove in the rock before using a copper drill. The tiny grains of sand actually do the cutting, with the drill guiding them. It works really well. I guess I was wrong about the jeweled tips.

After a long day, we go back to our hotel overlooking the Nile. At sunset the water is filled with sailboats called feluccas. I think this is how the Nile must have looked in ancient times, when boats traveled up and down the river like a highway.

March 18

We have become friends with Faisal, a carpenter from Cairo. We communicate with pictures and smiles. When he departs, I give him my carpenter's hammer. He is delighted. It was very special working with Faisal on this project. Perhaps his ancestors helped build the first obelisks. . . .

March 20

The workers help us assemble the wooden frame on top of the obelisk. We explain how to put it together through a friend who speaks both English and Arabic. The team does a magnificent job. We thank our friend for the excellent translations.

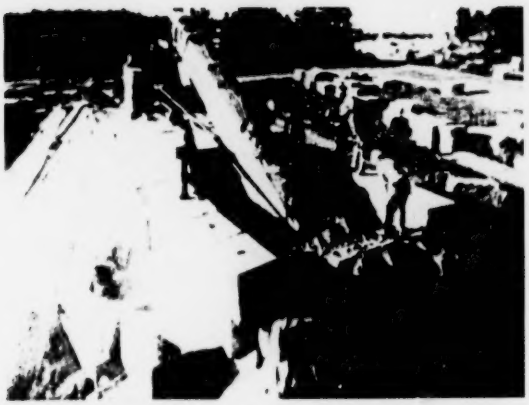
March 23

Wyly reminds us that we are about to re-enact a construction process that could be thousands of years old. We have a moment of silence to think about all the builders before us. Then we review five hand signals: pull, walk, hold, release, and—just in case—run. Forty workers in long white robes and turbans begin to pull, chanting, "Hela hop!" *[A traditional working chant that has no meaning in Arabic—it may come from the ancient Egyptian language.]* The obelisk's tip rises slightly. More pulling. I rush to put a block under the obelisk, to hold it at its new angle.

March 24

Bad news. During the night, the ropes stretched. We try using a counterweight. Our frame holds, but the ropes continue to stretch and slip. The obelisk slides toward the edge of the wall. Late in the day, a big rope breaks. The obelisk looks like it might fall. Entire project is called off.

Wyly and I can't believe it's over. If we had more time, we think we could succeed. But we must return home with the obelisk still lying on the ramp. I hope NOVA will want to try again soon.

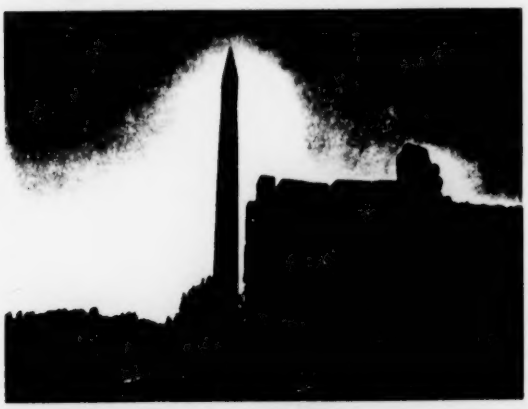


The "sand method" of raising an obelisk

One More Try

After he returned home to Massachusetts, Rick and his wife Laura decided to try once more to raise an obelisk. They assembled a group of friends and family to raise a 25-ton [23 metric tonnes] obelisk in a local quarry.

The team positioned the obelisk's base over a stone box filled with sand. The obelisk's pedestal lay beneath the sand. As the team shoveled sand from beneath the obelisk, its base sank lower, tilting the top end into the air. Using muscle and well-tested ropes, they slowly lowered the stone into a groove in the pedestal and tipped the obelisk upright. The crew was proud: It was the first obelisk raised using ancient Egyptian technology in more than 2,000 years.



Success at last!

8

What were some of the challenges of making this film?

Julia: It was difficult because we weren't just filming ongoing scientific research, but also managing a huge construction project. We were trying to do something that hadn't been done successfully in thousands of years. And being in Egypt made it more challenging because of language and cultural differences. There were also all kinds of problems moving our obelisk to the filming site. The tires of the flatbed truck we put it on popped, the axle broke. . . .

Were there any particularly magical moments during your trip?

Julia: One time, we went up a mountain to an old tomb that is usually closed to the public. Our guides had to remove stones blocking the doorway. There is an official ritual for doing this, which includes breaking a wax seal and signing a book to document that the tomb has been opened. Inside, the walls were covered with paintings more than 3,000 years old.

As we left, one of our hosts suggested, "Let's take a rest over here," pointing to a cliff face with doors cut into the rock. Then someone appeared out of nowhere with a tray of scalding hot tea. Even in the hottest weather, Egyptians often drink very hot, strong tea. It actually seems to cool you down. So, there we were having a little party halfway up a mountain in front of a 3,500-year-old tomb! It may seem strange, but it probably wasn't that different from what the ancient Egyptians did. They visited their ancestors' tombs often and may have held memorial celebrations for years after their relatives' deaths.

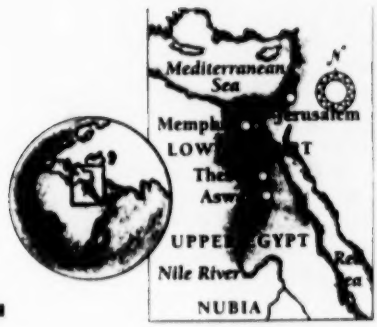
How did you feel about calling off the project?

Julia: For safety reasons, we had to again abandon our attempt to finish raising an obelisk. It was extremely frustrating. It was almost exactly what had happened on the first obelisk film and what I had tried to prevent. I thought I'd have a whole film by the time I left Egypt, but I didn't.

Why do you think the final attempt was successful?

Julia: We learned more about raising an obelisk each time. In the first film we tried to raise it from too low an angle. The second time we relied more on ropes and wood, but it was very difficult to control. But in a side experiment, one team member, stonemason Roger Hopkins, successfully raised a small obelisk using sand. In Massachusetts, Rick and Laura adapted Roger's sand method. They used ropes and a wood rigging again, but modified their design. Finally, things seemed to come together, and it worked. So each attempt was valuable and contributed to the final success . . . thank goodness!

Pharaoh's Obelisk



Ancient Egypt

Egypt is a modern name for this region. Its ancient inhabitants called their land "Kemet," a word referring to the rich, black soil along the Nile River. Unlike many rivers, the Nile flows north rather than south.

The great doors open, and I enter the enormous audience chamber. On a gold throne sits the most powerful person in the world: Hatshepsut (haht-shep'-soot), pharaoh of Egypt.

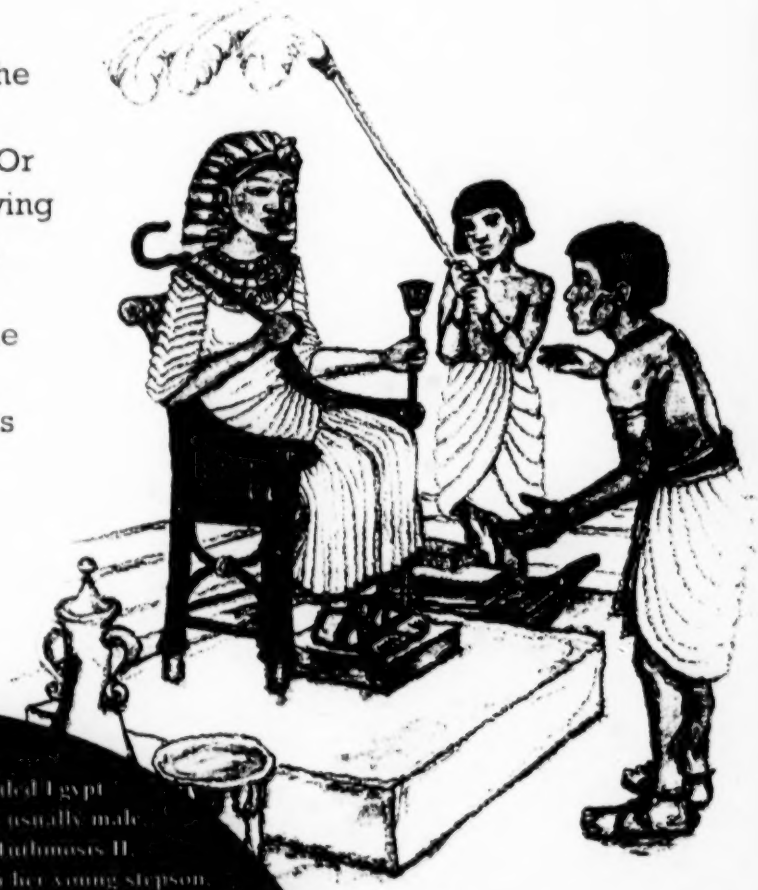
"Come forward, Master Builder," she orders. Her voice echoes in the chamber. I tremble. Unfortunately for me, Hatshepsut has reason to be angry.

She speaks. "What happened to the obelisks I ordered?"

"Your majesty, it was not my fault. Or the fault of my workers. We were carving the second obelisk out of the ground when a crack formed. It is unusable."

The pharaoh frowns. But finally she says, "Then begin another one immediately. I want a pair of obelisks to honor my father, Amun-Ra."

I sigh with relief. She has given me another chance. Now I will create the grandest obelisks the world has ever seen.



Hatshepsut

was a woman pharaoh who ruled Egypt around 1500 B.C. Pharaohs were usually male, but after her husband, Pharaoh Tuthmosis II, died, Hatshepsut shared the throne with her young stepson, Tuthmosis III. After several years, she declared herself the sole pharaoh. To strengthen her image, Hatshepsut often had herself depicted wearing a false beard. Calling herself the daughter of the mighty sun god Amun-Ra, she ordered the raising of some of ancient Egypt's largest obelisks in his honor.

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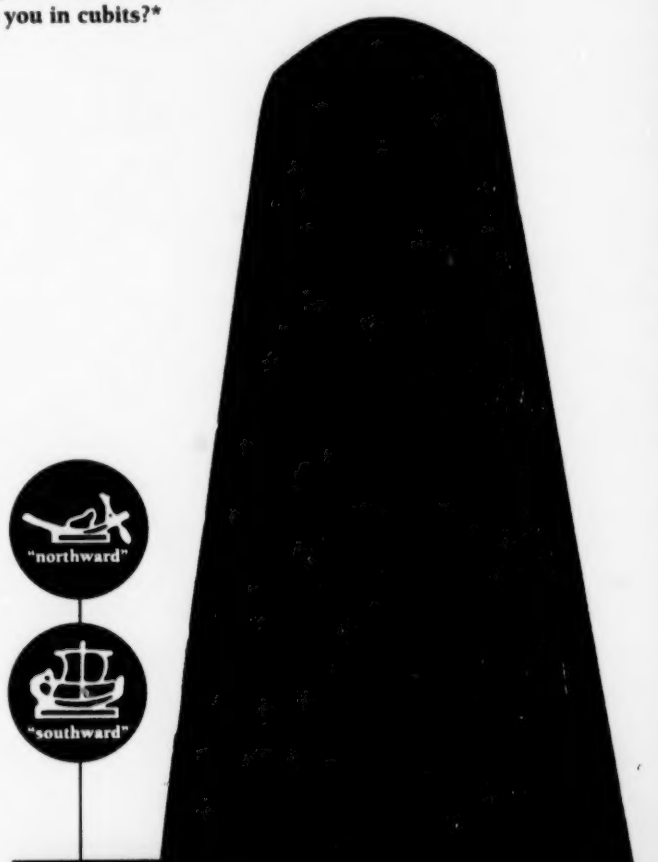
Ancient Measurements
The ancient Egyptians used a unit of measurement called a cubit (kyoo´-bit). One cubit is equal to 1.72 feet (52.5 centimeters). How many feet long was the piece of granite the Master Engineer found? How tall are you in cubits?*

DAY 1
I return to the Aswan (ah´-swahn) quarry, the source of the finest granite. I must find another slab long enough and thick enough to be carved into an obelisk.

DAY 7
After days of searching in the hot sun, I have found the perfect slab of granite. It is massive—52 cubits long. The workers begin shaping it with pounding balls made of dolerite (doh´-leh-rite), a mineral hard enough to break up granite. Dozens of men sit atop the stone and chip away at it, little by little.

DAY 190
The workers have almost worn their fingers to the bone, scraping away the sides and ends of the obelisk. Now they are ready to free the bottom face from the ground. To do this, they must lie on their sides and pound inward. Eventually, they will be underneath the obelisk—beneath tons of solid rock. Meanwhile, other workers begin to polish the top. They pour sand over the obelisk and rub flat stones along it, smoothing the surface.

DAY 235
The top of the obelisk is smooth at last. Now the craftsmen begin the important work of carving the pharaoh's message into the rock.



Obelisks (ah´-buh-lisks) are tall, pointed stone monuments. Ancient obelisks were usually covered with symbols called hieroglyphs (hy´-roh-glifs) proclaiming the pharaoh's greatness and declaring devotion to the gods.

Hieroglyphs could be written from left to right, right to left, or top to bottom—unlike English. Some hieroglyphs stood for sounds, like the letters in the English alphabet. Other hieroglyphs were pictures that stood for entire words. For instance, the hieroglyph indicating the direction "northward" is a boat without a sail. Since the Nile flows north, a boat heading north is carried by the current and needs no sail. The hieroglyph indicating the direction "southward" is a boat with a sail.

*The piece of granite was about 90 feet long (52 cubits x 1.72 feet/cubit). To calculate your height in cubits, divide your height in feet by 1.72 feet/cubit.

DAY 241

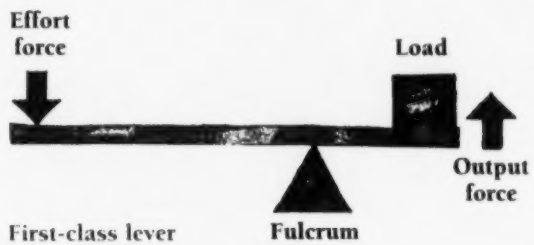
A great event occurred today. The men were using long wooden poles as levers to rock the obelisk from side to side. Only a thin spine of rock still connected the obelisk to the hillside. Suddenly, with a loud cr-r-a-a-c-k-k-k! that echoed through the quarry, the obelisk broke free.

DAY 312

The carving is complete. I call the artisans to cover the tops of the obelisks with the golden metal called electrum. When the obelisks are raised, their tops will gleam as though they are bringing the sun itself down to Earth.

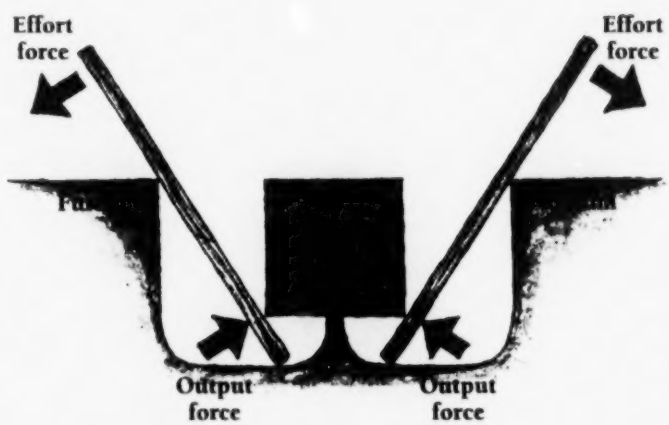
1

A lever is a simple machine that makes work easier. A lever can change the direction and the amount of force that is applied to a weight being lifted or moved, called the load. A lever consists of a rigid bar and a turning point, called a fulcrum. In a first-class lever, the fulcrum is located between the load and the effort force. The output force acts in the opposite direction from the effort force.



2

The Egyptians' poles acted as first-class levers. The Egyptians applied the effort force to the ends of the poles, the rock edges acted as the fulcrums, and the obelisk was the load. The levers changed the direction of the effort force pulling down on the poles to the output force pushing up on the obelisk.



11

DAY 319
The two obelisks are finally moving. Each one rests on a wooden sledge. It takes 1,500 men with strong backs to pull each sledge. But by tomorrow we should reach the banks of the Nile, where the barge will be waiting. We'll use a ramp to load the stones onto the barge. Then 30 boats, each with 30 rowers, will tow us down the river.

The NOVA team's boat model

DAY 348
The trip was uneventful—the Nile carried us in her arms all the way to the capital city of Thebes (theebz). Now all that remains is to move the obelisks into position.

DAY 381
It is done. The obelisks are raised. They will stand forever, tall and proud, proclaiming Hatshepsut's devotion to Amun-Ra.

Find Out More

read

Woods, Geraldine. *Science in Ancient Egypt (Science of the Past).* New York: Franklin Watts, 1998.
This book describes ancient Egypt's architecture, medicine, technology, and knowledge of astronomy and time.

Greenblatt, Miriam. *Hatshepsut and Ancient Egypt.* New York: Benchmark Books, Marshall Cavendish Corp., 2000.
Learn about the first successful female pharaoh. You'll read how Hatshepsut became a pharaoh and why the records of her reign were wiped out until recently.

Crosher, Judith. *Technology in the Time of Ancient Egypt.* Austin, TX: Steck-Vaughn Company, 1998.
Clear, step-by-step diagrams combined with art and artifacts give insights into the skills that made the ancient Egyptians successful. Activities show you how the Egyptians developed their technologies and let you adapt them for yourself.

visit

www.clpgh.org/cmnh/exhibits/egypt/
Explore the Carnegie Museum of Natural History exhibitions on Egypt.

www.pbs.org/nova/lostempires/
Read and view slides about obelisks around the world. Interactive activities let you compare the size of an obelisk to a herd of elephants and raise a virtual obelisk.

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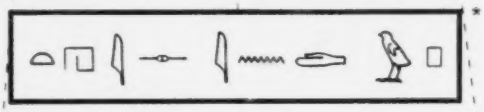
Hands-on Hieroglyphs

What You Need

- 1 sheet of notebook paper
- 1 sheet of construction paper
- colored pencils or markers
- scissors
- tape
- a quarter, metal washer, or other flat, heavy object

Studying the giant obelisks, you discover that Hatshepsut's Master Builder left a secret message among the hieroglyphs declaring her greatness. Use the hieroglyph guide below to translate the message.



Hieroglyph Guide

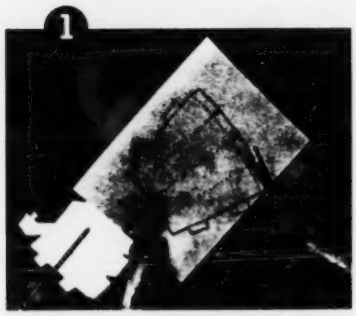
There is not an Egyptian hieroglyph to match every sound in the English language. Historians created the "alphabet" shown here by selecting a hieroglyph that is similar to each letter in the English alphabet.

13

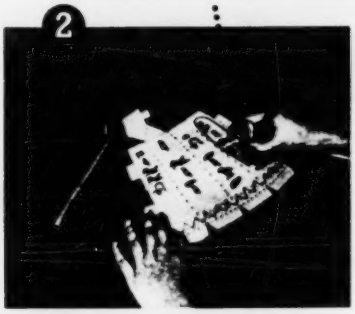
Here's how to build an obelisk that tells your story.

What to Do

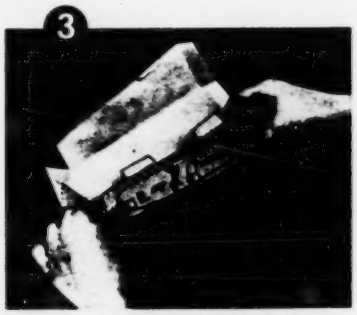
Be sure to sign your obelisk, Egyptian-style. After you write your name in hieroglyphs, draw an oval around the name. The oval containing the name is called a cartouche (kahr-toosh').



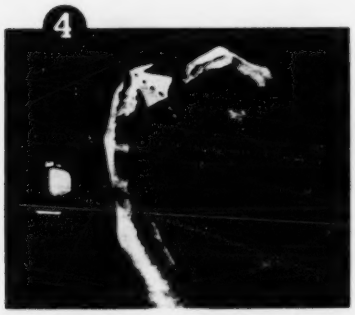
Trace the obelisk outline on the facing page onto notebook paper. Cut out the obelisk. Use it to trace the shape onto construction paper. Cut out the construction paper obelisk.



Draw a message on the sides of your obelisk for future generations to read. Use the hieroglyph alphabet and other picture symbols to tell something about yourself.



Following the dotted lines, fold the obelisk's four sides. Fold the four points on top. Fold back all the tabs.



Fold and tape the bottom tabs one on top of the next to form the obelisk's base. Put a loop of tape on two of the side tabs. Press the side tabs together to close up the obelisk.

Tape the tab on the top portion of the obelisk to the inside to form a pointy top. Then tape the top to the sides as shown.

To help your obelisk stand up straight, you can tape a quarter or other flat weight to the base.

Show your obelisk to a friend or family member. Have the person try to decipher your message using the hieroglyph guide. Is the translation correct? How is the person's attempt similar to the challenges faced by archaeologists trying to learn about ancient Egypt?

ROMAN BATH

The Roman Empire

At the time this story is set (A.D. 217), Romans wrote the date by stating which consuls, or public officials, were in power. Emperor Caracalla was the most powerful official. He ordered the building of the baths Marcus describes in his letter.

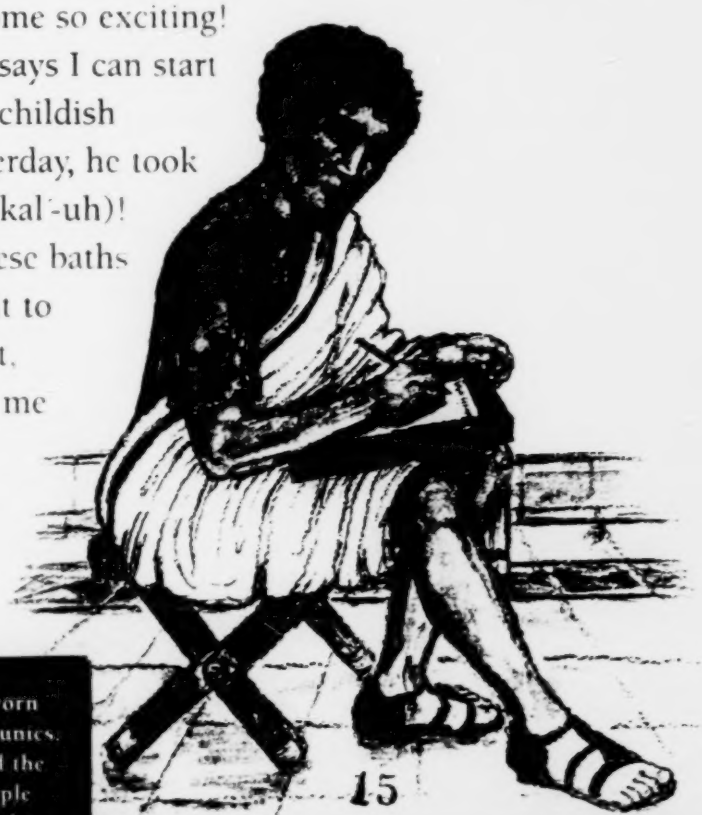
During this time, the Roman Empire stretched from modern-day Scotland to Syria. Roman customs spread throughout these lands, as did many examples of Roman engineering, such as roads and bridges.

Rome, when C. Praesens and
T. Extricatus were consuls

Dear Silvia,

My dear cousin, I hope this letter finds you doing well out there in Britannia. I know it's a Roman province, but I can't help thinking you're living in the wilderness.

Here in Rome, everything has become so exciting! I shall be grown up soon, and Father says I can start wearing a man's toga instead of these childish clothes. I think he means it, too. Yesterday, he took me to the Baths of Caracalla (kar´-uh-kal´-uh)! It seems like they've been building these baths for most of my life, and I couldn't wait to visit them. They are truly the grandest, most amazing baths in the world. Let me tell you about our visit.



TOGAS were robes worn over underdresses called tunics. Boys wore a version called the toga praetexta, with a purple stripe. It was a big event when a boy began wearing a man's toga virilis at about 14 or 15.

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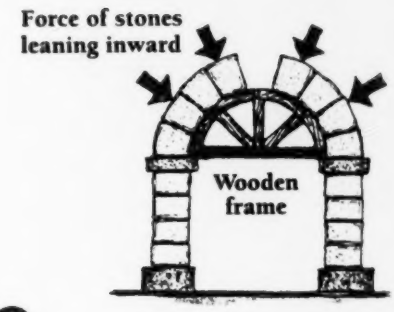
The Baths of Caracalla are almost like a city within in the city. They cover an area of 27 acres (110,000 square meters)! There are gardens, meeting halls, and places to buy food and drink. The bathing rooms themselves are decorated with marble, painted frescoes, and bronze. The columns are so tall that I got dizzy looking up at them. I had never been inside such enormous rooms.

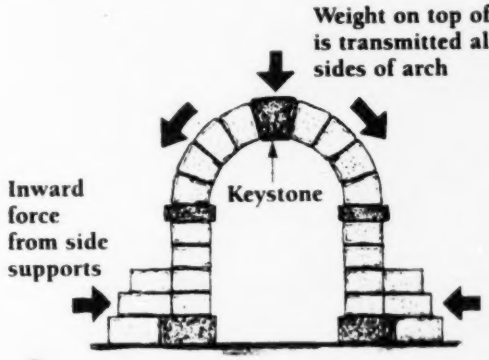
I thought going to these new baths would be peaceful and relaxing, but instead it was crowded and noisy. There were people everywhere. They were talking and shouting and singing so loudly I feared the mosaics would come right off the walls. As you know, they let everybody into the baths. Everywhere else, Romans are divided into classes—the rich, the workers, and the slaves. But here, everyone, rich or poor, bathes together. It's interesting, but it means there's always the chance someone will steal your clothes from the changing room.

Our first stop was the exercise courtyard, or palaestra (pah-lay'-struh), where I wrestled with some other boys. (Supposedly wrestling builds character, but I'm not sure how much I'm learning by getting my head dumped in the dirt.) In any case, I worked up a good sweat. After that, as usual, a slave covered us with sand and then scraped it off with a metal strigil (strih'-jil).



1

The Romans were able to build large buildings with high, curved roofs because they used arches. An arch is a curved shape that spans an open space. To build an arch, the Romans first built a curved wooden frame. Then they piled stones up and over the curving sides of the arch.



2

The center stone at the top of the arch, called the keystone, locks the lower stones in place. The weight of the arch creates a pushing force, called compression, along the sides of the arch. But the sides of the arch must be strongly supported, or the arch will collapse outward.

THE STRIGIL

was a metal tool used to scrape the bathers' bodies after they exercised to work up a sweat. Slaves would cover the bathers with sand or oil from a jar like this one and then scrape off the sweaty, dirty mixture. Although the Romans invented many things, including waterproof concrete and paved roads, they never invented soap.

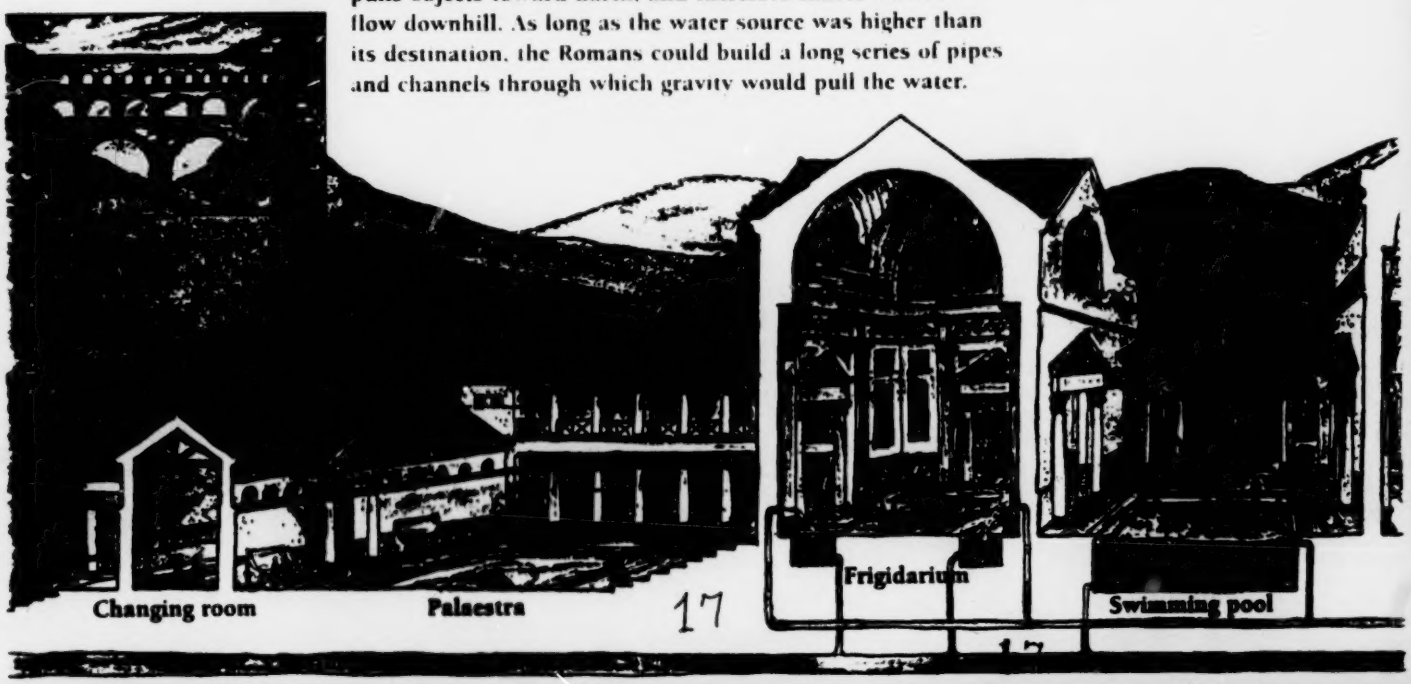
I was ready to get in the water after that, but Father said, "Not yet. You're old enough for a depilator." A depilator is a hair plucker! I lay down on a table, and a slave came in with some tweezers. Without warning, he plucked a hair right from my armpit. By Jupiter, that hurt! But the latest Roman fashion is that body hair is ugly, and everyone has it torn out.

Next we entered the tepidarium (teh-pih-dair´-ee-um). The air and water were nice and warm. It was wonderful . . . except for this man who sat near us, sneezing noisily into the water. Once we'd warmed up, we moved into the caldarium (kahl-dair´-ee-um). It was the hottest caldarium I've ever been in—we were glad we had those wooden shoes to keep from burning our feet on the floor.

The hot water was very relaxing. I didn't want to get out, so I tried to distract Father by asking him questions about the baths. I was wondering where all the water comes from, for one thing. It doesn't seem like there's enough water in the city itself for all the baths, fountains, and other uses. He explained that we Romans have built a system of water-carrying channels called aqueducts (ah´-kweh-dukts) that carry water down from the mountains. But then he said that it was time to move on to the frigidarium (frih-jih-dair´-ee-um). Getting into that cold water was really difficult after the hot caldarium.

When we were done, we dressed again. Outside the baths we strolled through the

Water for the baths was often supplied by the Romans' network of aqueducts. The Romans designed their aqueducts to harness gravity. Gravity is the force that pulls objects toward Earth, and therefore causes water to flow downhill. As long as the water source was higher than its destination, the Romans could build a long series of pipes and channels through which gravity would pull the water.



streets full of bustling shops. I convinced Father to stop at a popina (poh-pee´-nuh) for a snack. It's amazing how they keep the food warm by resting it over hot water—it's like a miniature bath. Father doesn't like the popinae—he says this "fast food" is just a fad.

Now that Father finally admits I'm growing up, perhaps he'll take me to the Colosseum to see a gladiator fight. Do you know, they can even fill the Colosseum with water and have mock sea battles?

Farewell, Silvia. I hope someday they build baths as grand as Caracalla in Britannia for you!

Your cousin,

MARCUS

READ

Macaulay, David. *City: A Story of Roman Planning and Construction.* Boston: Houghton Mifflin Company, 1974.
The Romans were masters of city planning. Follow the building of an imaginary Roman city, step by step, from houses to shops, public squares to temples.

Chrisp, Peter, and Andrew Haslan. *The Roman Empire (Make it Work! History Series).* Chicago: World Book, Inc. in association with Two-Can Publishing, Ltd., 1996.
This book contains recreations of ancient Rome with clear, practical instructions for model-making projects.

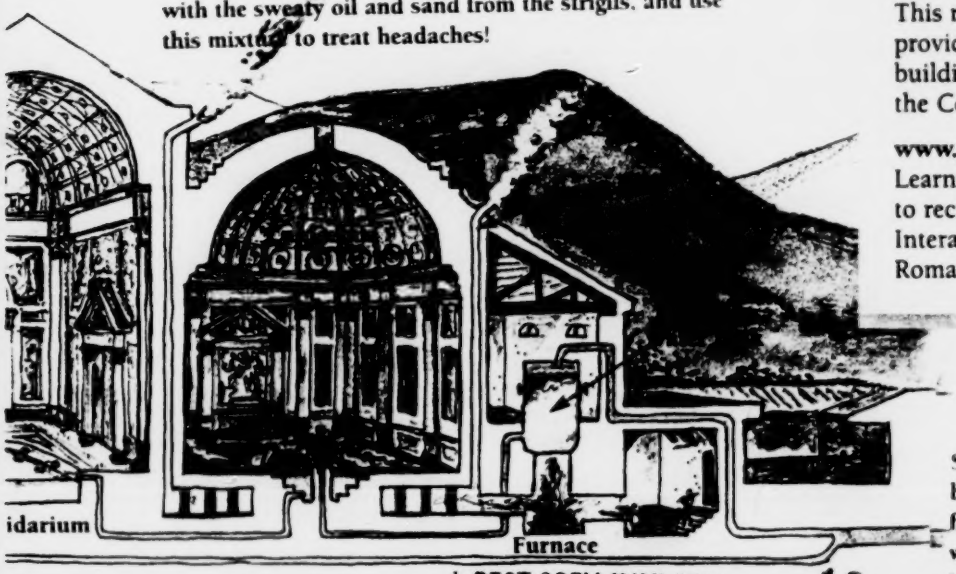
Snedden, Robert. *Technology in the Time of Ancient Rome.* Austin, TX: Raintree/ Steck-Vaughn Company, 1998.
Find out how Romans developed concrete and built bridges and dams that are still in use today. Activities let you adapt Roman technologies for yourself.

VISIT

www.unc.edu/courses/rometech/
This resource on Roman technology provides a directory of links on the building of specific structures, including the Colosseum, baths, and aqueducts.

www.pbs.org/nova/lostempires/
Learn about NOVA's expedition to Turkey to recreate a working Roman bath. Interactive activities let you explore a Roman bath and build a virtual aqueduct.

Though the Romans liked bathing for social reasons, they did not realize that their baths were not clean. In fact, they thought bathing could help cure disease, so the baths were often filled with sick people. The Romans would even gather up the scum that formed on the water, mix it with the sweaty oil and sand from the strigils, and use this mixture to treat headaches!



Slaves tended a furnace below the baths. The hot air flowed beneath the floor of the caldarium, heating the water. From there the hot air rose up into pipes, called tubuli, in the walls.

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STRAW-QUEDUCT

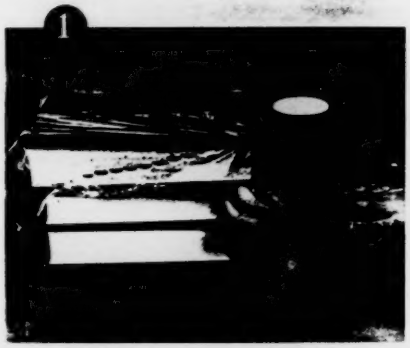
Aqueducts were one of the most important products of Roman engineering. The aqueducts enabled Romans to live in big cities where there otherwise wouldn't have been enough water to support so many people.

You can build a model aqueduct to explore how the Romans used the force of gravity to bring water to their cities.

What You Need

- several books (or anything else you can stack)
- plastic wrap or aluminum foil
- 3 paper cups
- a sharp pencil
- several plastic drinking straws
- masking tape
- 2 small plates
- water

What to Do



Make a stack of books a little taller than a paper cup. Cover the books and the table with plastic wrap or foil to protect them from any leaking water.

The Pont du Gard, a Roman aqueduct near Nimes, France

Use a pencil to poke a small hole near the bottom of one of the cups. The hole should be just big enough to stick a straw through it.

Push a straw through the hole. It should be a tight fit. A little bit of the straw should be poking into the inside of the cup. Seal the outside of the hole tightly with tape.

Place a small plate on top of the stack of books. Then place the cup with the straw attached on the plate. The plate should catch any water that drips from the cup.

Put the second cup next to the stack of books, beneath the free end of the straw. Place the other plate under this cup to catch drips.

Pour water into the higher cup to start your straw-queduct working. How does the flow of the water change if you change the angle of the straw leading down to the second cup? Two ways to adjust the angle are to move the straw around and to change the height of the stack of books. Try to find an angle that produces a gentle, steady flow of water. Here's another challenge: How much longer can you make your straw-queduct and still keep it from leaking?

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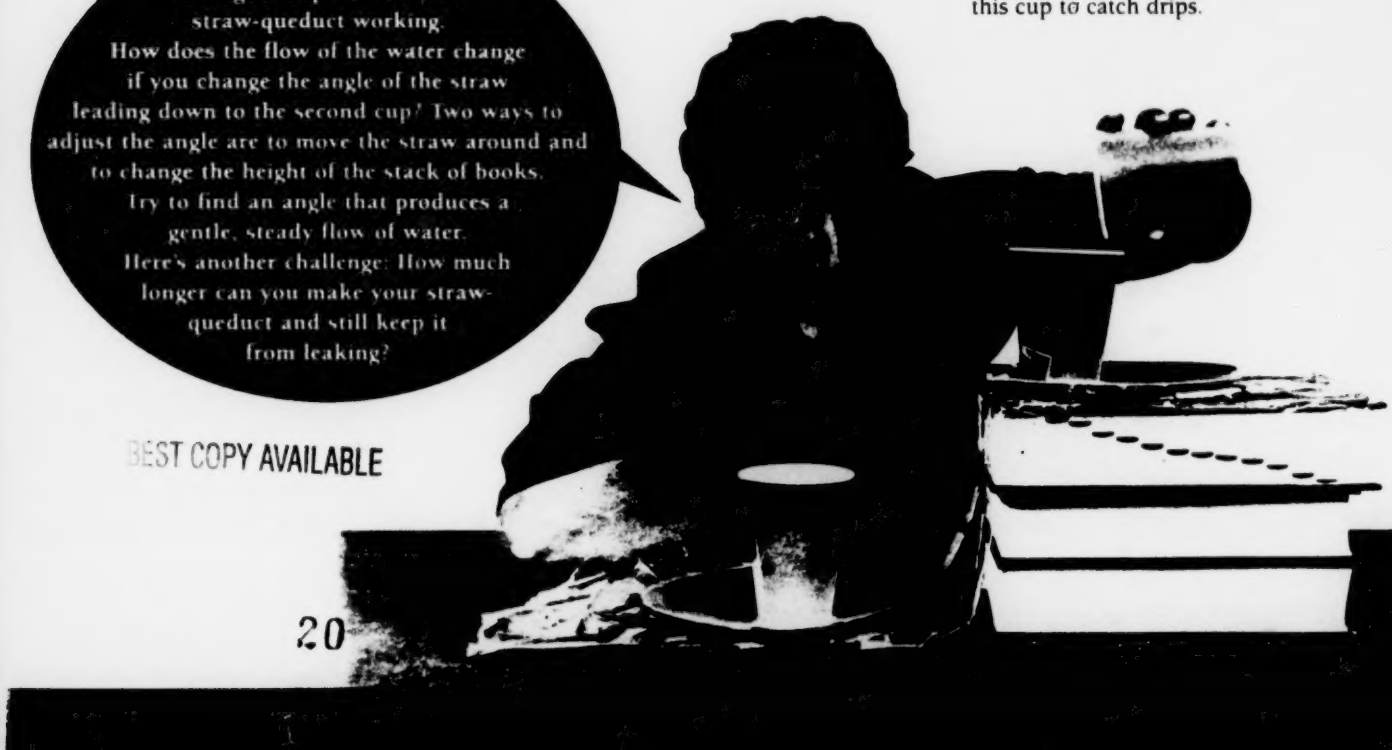
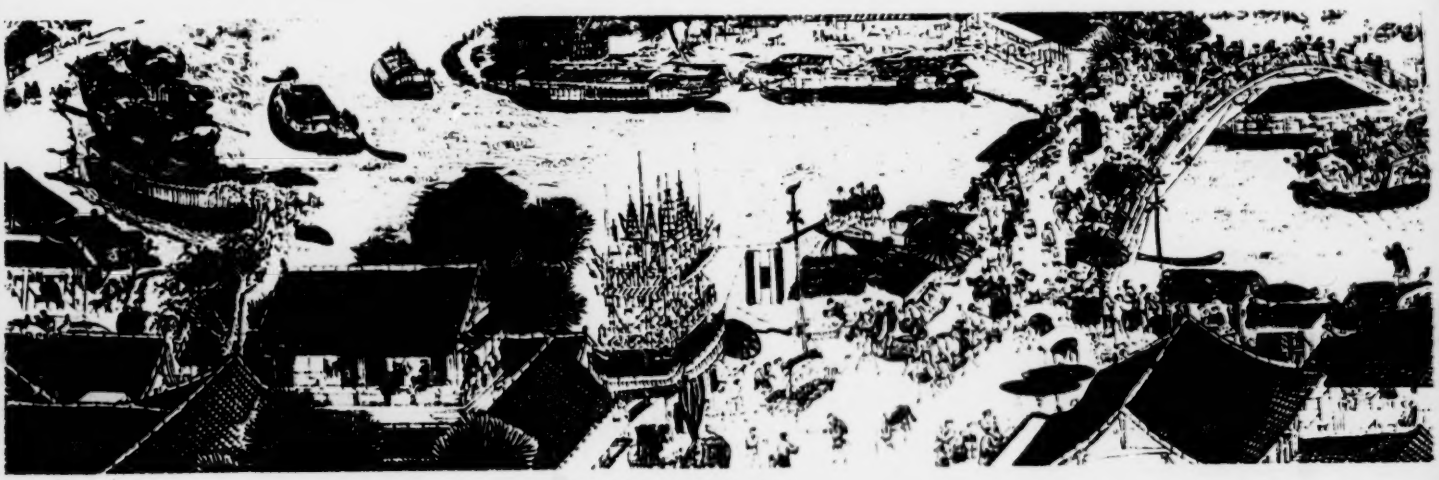


CHINA BRIDGE

A dynasty is a period of rule by a family. The Song dynasty ruled China from A.D. 960 to 1279. The Song emperors had two capital cities. Kaifeng, on the banks of the Bian Canal, was the capital until 1126. When tribes from the north conquered the northern part of China, the Song formed a new capital at Hangzhou, south of the Yangzi River.

This map also shows part of the Great Wall, which was built in an attempt to keep the northern tribes out of China. It is the longest structure ever built and the only human creation that is visible from space.

THE STRANGERS CAME OVER THE BRIDGE AT SUNRISE. WEI LIN HAD NEVER SEEN ANYTHING LIKE THEM BEFORE. OF COURSE, SHE WAS ONLY EIGHT AND HAD NOT SEEN MUCH OF THE WORLD. BUT SHE DIDN'T THINK HER GRANDFATHER HAD EVER SEEN MEN LIKE THESE BEFORE EITHER, AND HE HAD BEEN ALL THE WAY TO THE GREAT WALL. THE MEN WERE TALL, WITH SKIN AS PALE AS A LOTUS FLOWER. THEIR EYES WERE BIG AND ROUND, AND THEIR CLOTHES WERE VERY STRANGE. WHO WERE THEY? AND WHAT WERE THEY DOING ON THE RAINBOW BRIDGE?



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Wei Lin and her grandfather were going to the market stalls on the bridge. The path to the river was not crowded so early in the morning. Morning was also the best time to ask her grandfather questions about his work. Most people expected questions about bridges and buildings to come from boys. Girls were supposed to ask about embroidery, weaving, and silkworms, but from what Wei Lin could tell, the silkworms knew their own business. So she wanted to know about what her grandfather built—bridges.

Then she noticed the three strangers. They were traveling with Lo Ping, one of the Emperor's advisors, so they were obviously there with permission. Two of the men were older, with bushy beards. The third stranger was young, hardly older than her oldest brother, Wei Lin thought. He was looking around with great interest, as though he had never seen anything like the busy riverbank scene before.

"Who are those men?" Wei Lin asked.

"Questions, always questions," Grandfather sighed. "They are foreigners from beyond the mountains, even from beyond the great deserts. They are visiting from far away in the West. I have heard they want to trade with our people." Grandfather lowered his voice. "But we must be careful not to give them our secrets."

"What could I possibly know that they would be interested in?" Wei Lin wondered to herself.

While her grandfather went to speak to a merchant, Wei Lin wandered onto the bridge. She leaned over the side and gazed down at the intricately woven wooden beams holding it up. Could this be the secret the strangers wanted? When she looked up, the young stranger was standing beside her. He spoke Chinese with an accent, but she could understand him.

"I noticed you up here, looking around," he said. "May I join you? I am hoping to learn something about your country. My name is Marco Polo."

Wei Lin thought she had never heard such a strange name. But she could hardly believe this foreign visitor was speaking to her. And now he was asking a question!

"Perhaps you can tell me what this is," Marco Polo said, holding out a small piece of paper with a complicated design on it. "I have seen people giving such things to each other. Is it a message of some kind?"

Wei Lin laughed. "It's jiao zi (jhow zee), pocket money," she said. "Don't you have money where you come from?"

The stranger seemed excited to learn this. "Ah, paper money," he said. "How different! We have money in my country, but it is round and made of metal." He pulled Wei Lin over to

THE RAINBOW BRIDGE took its name from its high, arching shape. The bridge's height allowed boats to pass beneath it. You can see a Rainbow Bridge in this portion of a 30-foot-long (9 meters) painting of a scroll from the Song dynasty, called "Going Up the River During the Qingming Festival." The bridge bustles with activity: stalls selling food and other goods, and people talking as they walk along.

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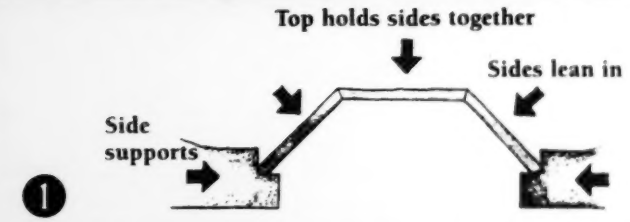
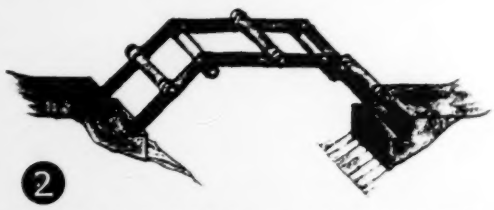


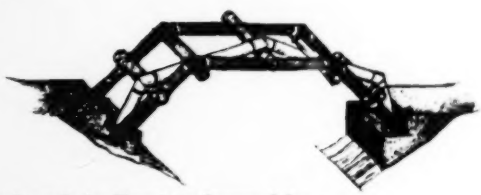
1

An arch is a shape that spans an open space, like a bridge over a river. An arch consists of two sides that lean inward plus a top that holds the sides in place. A weight pressing down on top of the arch is spread out and down the sides of the arch and into the ground. The two sides must be strongly supported, or the arch will collapse.



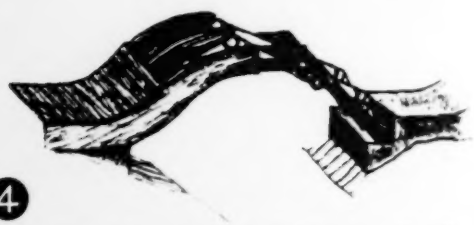
2

The Rainbow Bridge's strength comes from two types of arches woven together: a three-sided arch and a four-sided arch. First, the three-sided arch (red) is built. The sides are raised into position, and two beams are placed across the top. Crosspieces (blue) connect the sides of the bridge at five points.



3

Next the four-sided arch (yellow) is formed by weaving beams over and under the crosspieces. The two arches lock together. The weaving results in a weight on the bridge being spread in several directions. This makes the bridge very strong.



4

More beams are woven into the gaps. Finally, curved beams are inserted to give the bridge a gentler curve that is easier to walk across.

a nearby stall, where people were tying together stacks of paper covered with Chinese characters. "And what are they doing with paper here?"

"They're making books, of course," answered Wei Lin, surprised by the question. "First, they print each page on a press that has the characters all laid out in the right order. They can make many copies of the page, all the same. Then they move the characters around to make the next page, and . . ."

She stopped suddenly, noticing his embarrassed look.

Marco Polo was rubbing his forehead. "At home I am considered very smart. But here I feel like an infant who knows nothing. Everything is so new and different—your money, your writing, the drink you call tea—even this bridge! In my country the bridges are made of heavy stone, with piers in the middle of the river."

Aha! He had finally mentioned the Rainbow Bridge. Wei Lin knew she shouldn't tell its secret, but she felt sorry for this strange young man. Besides, he was so interested that she couldn't help showing off her knowledge. She whispered, "I know what you really want to learn. My grandfather has made this sort of thing many times. I can tell you everything."

"But you are just a child! You know the secret to making something so delicate and beautiful?" he asked, amazed.

"Yes, of course. It begins with wood."

"Wood," he said eagerly. "Then what?"

"First you build the two sides. You use bamboo rope to tie the wood beams together. The top beam holds the two sides in place. The sides must be firmly anchored in the

ground on either side of the river."

The man blinked. "Over a river? Is there much water involved, then?"

Wei Lin shrugged. "Well, it doesn't have to be a river. It could be over a gorge."

"A river *or* a gorge?" the stranger said, confused. "What happens next?"

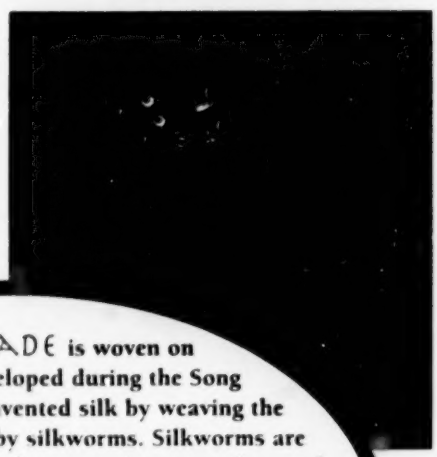
"Then," she continued, "You add more beams, over and under the crosspieces, like weaving. This makes it stronger."

The stranger shook his head. "*Like* weaving? I don't understand. What does tying a bunch of wood together with bamboo over a river have to do with making silk?"

Surprised, Wei Lin said, "Silk? Why, nothing! I was telling you how to make a Rainbow Bridge! You wanted to know how to build something delicate and beautiful. Have you ever seen anything more delicate and beautiful than a Rainbow Bridge?"

Just then, her grandfather called out, "Granddaughter!" He approached and said scoldingly, "It is not polite to occupy this man's time. I hope you haven't told him anything, er, improper?"

Wei Lin smiled, relieved. "No, Grandfather, I haven't told him anything at all."



SILK BROCADE is woven on complex looms developed during the Song dynasty. The Chinese invented silk by weaving the strong threads produced by silkworms. Silkworms are not actually worms, but the larvae, or immature form, of a type of moth. When the larvae build cocoons, their bodies produce a liquid substance that stiffens into threads when exposed to air. For centuries, the Chinese guarded the secret closely. Eventually, the technique of silkmaking spread to the rest of the world.

FIND OUT MORE

READ

Beshore, George. *Science in Ancient China.* New York: Franklin Watts, 1998. Between 2,500 and 500 years ago, the Chinese knew more about science and technology than any other people. Their knowledge of compasses, calendars, antiseptics, and acupuncture had a huge impact on later scientific advances.

Temple, Robert K. G. *The Genius of China.* London: Motti Media Books, 1998. Suspension bridges, fishing reels, and playing cards were all invented by the Chinese. This book covers 3,000 years of science and technology in China.

Williams, Suzanne. *Made in China: Ideas and Inventions from Ancient China.* Berkeley: Pacific View Press, 1996. Find out how the Chinese drilled wells for natural gas to light their streets, raised insects to produce silk, and invented rudders and moveable sails so their ships could sail into the wind.

VISIT

sin.fi.edu/tfi/info/current/inventions.html
Tour the catalog of ancient Chinese crafts and inventions at the Franklin Institute in Philadelphia.

www.pbs.org/nova/lostempires/
Read about bamboo, Rainbow Bridges, and the many inventions of the Song dynasty. An interactive activity lets you test different styles of bridges.

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MAKE A BRIDGE

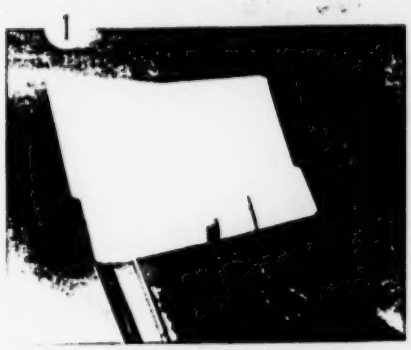
Chinese engineers built different types of bridges in different parts of China. The type of bridge depended on the natural materials available in each area, as well as the shape of the land. For example, in some flat, coastal areas, the Chinese built long, low stone bridges. In more mountainous areas, they built swaying suspension bridges from ropes made of twisted and braided bamboo.

Several factors influence the choice between building a beam bridge or an arch bridge in a particular location. One difference is that there is more room for boats to travel under an arch bridge than under a beam bridge. In this activity, you can explore other differences in these two basic bridge designs.

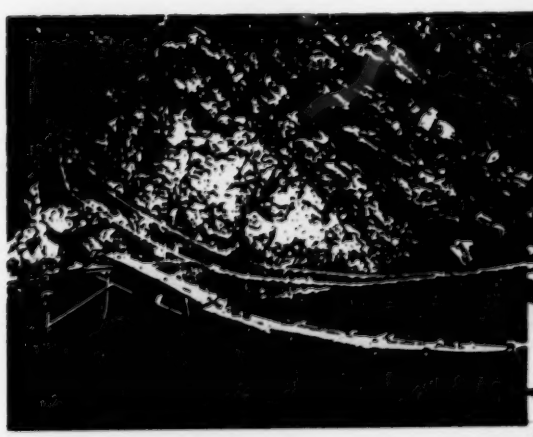
What You Need

- **manila file folder (or other heavy paper)**
- **ruler**
- **pencil**
- **scissors**
- **two books or blocks of about the same size and weight**
- **pennies**

What to Do

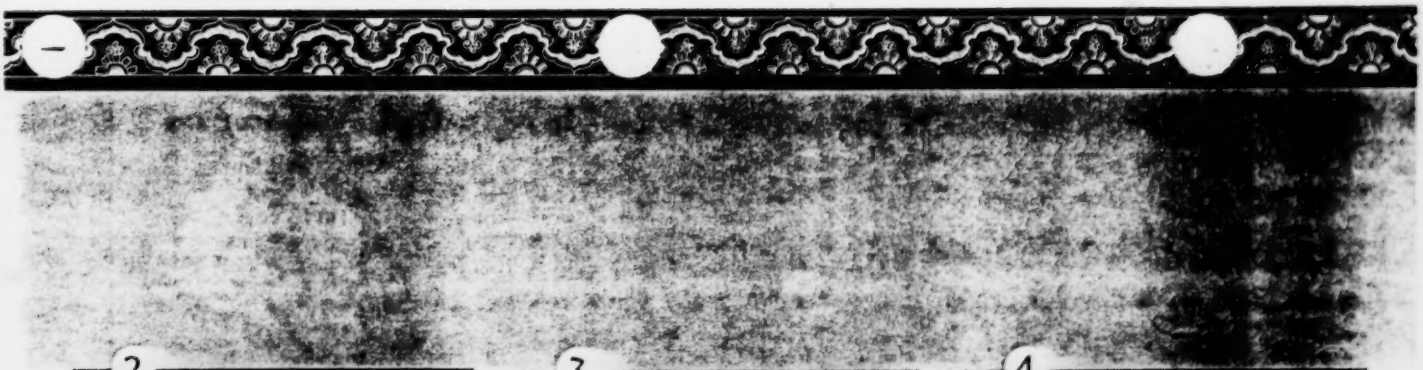


Measure and cut a strip of paper from the file folder. The strip should be 11 inches (28 centimeters) long and 4 inches (10 centimeters) wide. This is your bridge surface.

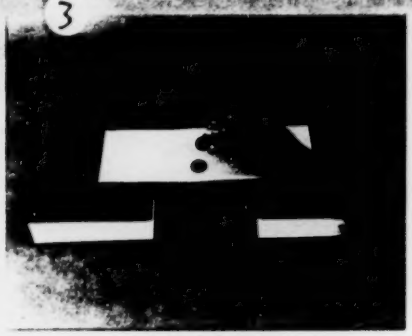


Rope suspension bridge

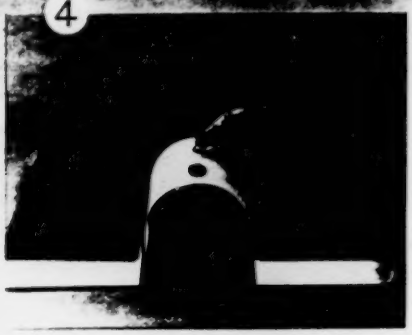
Stone bridge with piers



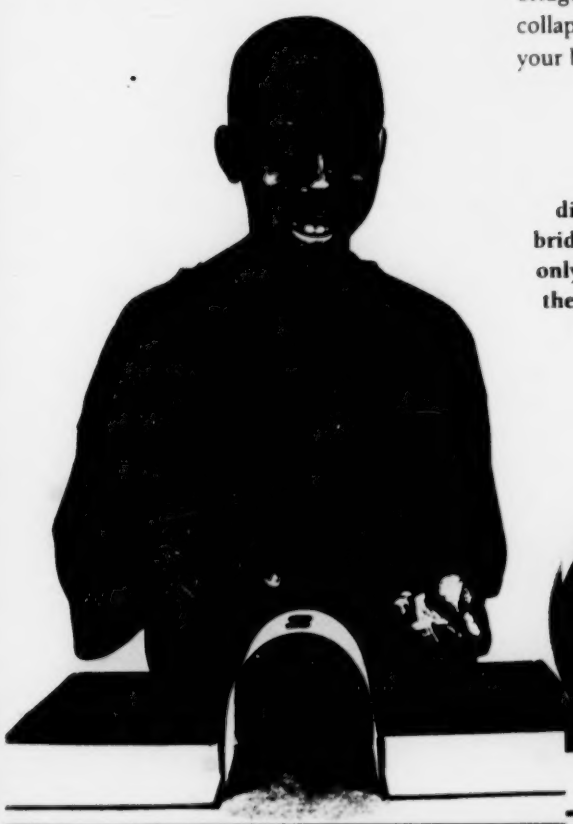
Place the books 5 inches (13 centimeters) apart on a flat surface. Your bridge must cross this gap.



To model a beam bridge, place the bridge flat across the two books. Now place pennies on the center of the bridge, one at a time, until the bridge collapses. Record how many pennies your beam bridge supported.



To model an arch bridge, bend the paper into an upside-down u-shape and place it between the two books. The books should still be 5 inches (13 centimeters) apart. Now test and record how many pennies the arch bridge can support.



You have just observed the difference in strength between a beam bridge and an arch bridge. Notice that the only factor you changed was the shape of the bridge—you used the same material, the same supports, and the same gap width in each case.

Now design your own experiment to answer one of these questions or another question of your own:

- **Which material (cardboard, aluminum foil, manila folder, construction paper, etc.) holds the most weight in an arch bridge that spans a 5-inch (13 centimeters) gap?**
- **How does the width of the gap affect how much weight an 11-inch (28 centimeters) beam bridge (or arch bridge) can hold?**
- **How does the size of the supports affect how much weight each style of bridge can hold?**

Medieval Siege

The year is A.D. 1304. A mighty English army led by King Edward I swarms around Stirling Castle in Scotland. Knights on horseback thunder across the fields toward the castle walls. Foot soldiers bearing great spears and axes rush the gates. Other soldiers use large wooden machines to hurl stones at the castle, but the machines are too far away to do much damage. Nothing the English do can overcome the strength of the castle. Safe behind its walls, the Scots laugh.

But the guards on the castle towers have noticed many carpenters going to work behind a large wooden shield. They cannot see what the carpenters are building, but the work is taking many weeks. Then one day, the shield is removed to reveal an enormous machine. It is far, far bigger than any other machine on the battlefield. It has a massive frame and a long central beam, like the neck of a giant animal.

"A dragon!" one of the defenders cries.

But it isn't a dragon. It's something much worse—the doomsday weapon of the Middle Ages.

The trebuchet (treh'-boo-shay).

Medieval Britain

In the Middle Ages, the rulers of England, Scotland, and Wales fought frequently to control different areas of land. Edward I who was the king of England from A.D. 1272 until 1307, was desperate to reclaim Stirling Castle. The Scots had captured Stirling in 1299 by surrounding it and cutting off supplies. On the brink of starvation, the English troops inside had surrendered.

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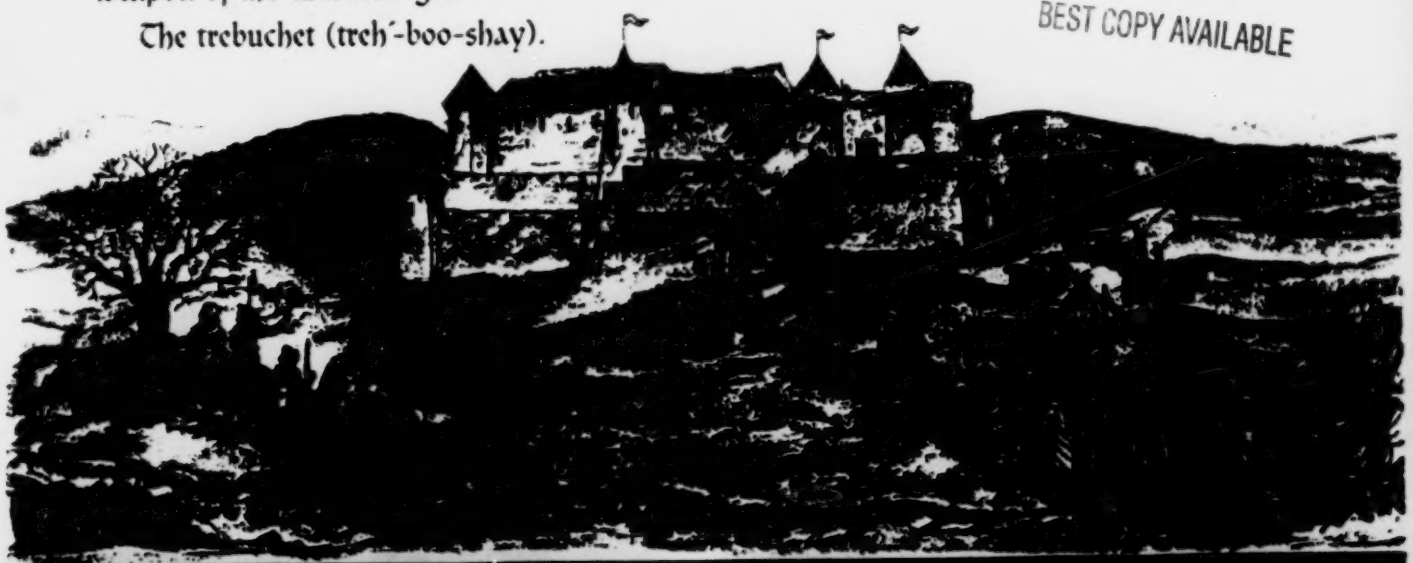


A month earlier, King Edward was pacing back and forth in his tent, thinking about the problem of Stirling Castle. It was too strong to attack directly. The Scottish archers and crossbowmen could pierce his knights' armor with their arrows from 200 yards (183 meters) away. He himself had been struck by a crossbow bolt while riding around the castle. How could he attack the castle from a distance that would protect his army?

The best weapon, he knew, was the trebuchet, which had come to Europe from China and Arabia. The trebuchet was a missile-throwing war machine that could fling stones great distances. But the trebuchets he already had were not large enough for such a mighty castle as Stirling. So he ordered his engineers to design a much bigger trebuchet, powerful enough to smash the castle walls to rubble.

Edward's engineers set to work immediately. They had no computers to help them. In fact, the mathematical explanation of how a trebuchet worked wouldn't be developed for nearly 500 more years! But through trial and error, the builders made their trebuchet work.

Edward's men cut huge timbers from the forest to build the machine. Few of the craftsmen could read or write, but they were skilled carpenters. Using only hand tools, they built a frame that could support a throwing arm weighing several tons. The trebuchet was held together mostly with pegs and grooves, requiring only a few nails. As the carpenters worked, they gave the trebuchet a name that matched its fierceness: They called it "Warwolf."

Now, watching from within the walls of Stirling Castle, the Scots see Warwolf rising in the distance. They know there is nothing they can do. If they shoot arrows at the trebuchet, most will fall short of the mark. Those that sail far enough will be deflected by a wooden shield covering the soldiers around the trebuchet. The Scottish commander, William Oliphant, sends a messenger to Edward offering to surrender.

28

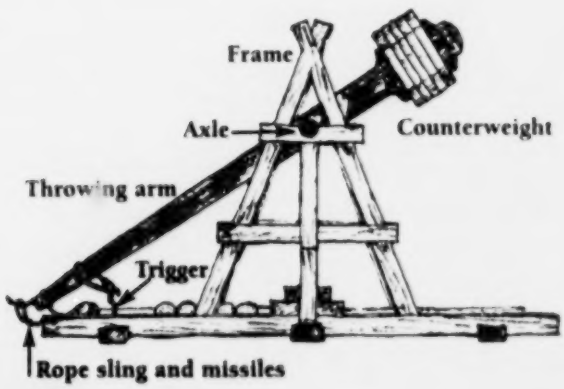
Attacking a mighty castle was no easy task. Invaders had to overcome water filled moats, high stone walls, and defenders who fired arrows and hurled stones from the castle walls. The attack, called a siege (seej), could drag on for several months. A siege required many soldiers and horses, as well as weapons such as the trebuchet.

Trebuchets were used to throw heavy rocks, as well as other things. Attackers would sometimes fling dead animals over the castle walls to spread disease—or to lower the defenders' morale.

King Edward is furious. After all this work, he wants to see his new machine in action! He sends a message to the Scots, saying that he will not accept their surrender until he has fired Warwolf. The Scots watch, terrified, as the king's men roll a massive stone ball into the thick rope sling. The sling end of the throwing arm is held down by a rope attached to a metal hook called the trigger. Then the captain yells "Shoot!" and a soldier cuts the trigger rope free. The heavy counterweight drops to the ground, the long throwing arm shoots upward, and the sling swings out and up. Warwolf lets loose its first strike.

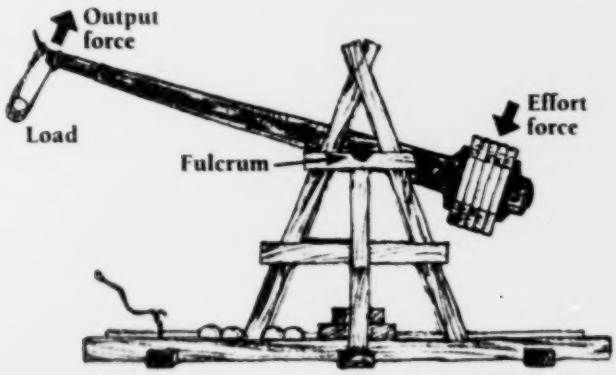
From the castle, the trebuchet looks like a giant serpent raising its head. Then the heavy ball arches into the sky. The ball looks tiny at first. But as it descends, the ball seems to grow bigger and bigger, until it crashes down with thunderous force. The ground shakes from the impact. Edward watches as missile after missile rains down. At last the wall crumbles, and he allows the Scots to come out and surrender.

The story of Warwolf shows the power of the trebuchet and its builders. The engineers who solved the problem of attacking a castle from a safe distance were the victors of the day.



1

A trebuchet consists of a giant throwing arm with a very heavy weight, called the counterweight, on the short end. A rope sling is attached to the other, longer end. A large rock or other missile is placed in the sling. The light end of the seesaw, with the sling, is held down by a rope attached to a hook called a trigger.



2

When the trigger is released, the heavy counterweight falls. As the counterweight drops down, the long end of the throwing arm rises rapidly. The sling swings out behind it.

The trebuchet's throwing arm acts as a first-class lever. (To review how levers work, turn to page 8.) The sling and missile are the load, the axle is the fulcrum, and the falling counterweight applies the effort force.

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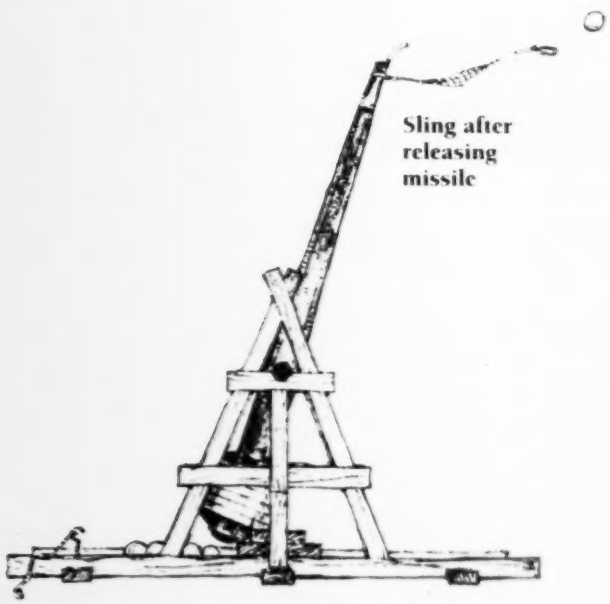
Some historians think that Edward used heavy lead rings as the counterweight on his trebuchet, as shown here. But some pictures from the Middle Ages show a different style of counterweight: a hanging wooden basket filled with rocks. Not only was the swinging-basket counterweight cheaper and easier to build, it made a more effective weapon. As the heavy end of the throwing arm fell, the weight in the basket dropped nearly straight down, instead of in a circular path like the lead-ring counterweight. This transferred additional output force to the missile as it was released.



3

When the sling reaches the top of the arc, one end slips off the hook. The missile flies out of the sling. (Imagine sitting on a seesaw with your feet on the ground, when an elephant suddenly jumps on the other end. You'd shoot into the air in the same way as the missile.)

Through trial and error the medieval engineers learned that a shorter sling caused the stone to be released earlier, fly at a higher arc, and travel much farther. However, the sling couldn't be too short, or the stone would fly straight up into the air—and straight back down onto the heads of the attackers!

read

Gravett, Christopher. *Castle.* New York: Alfred A. Knopf, 1994.
This book contains detailed illustrations and descriptions of all aspects of life in and around medieval castles.

Hart, Avery, and Paul Mantell. *Knights and Castles (Kaleidoscope Kids Book).* Charlotte, Vermont: Williamson Publishing Co., 1998.
Experience life in the Middle Ages with 50 hands-on activities, from playing medieval games to keeping time with a homemade hourglass.

Langley, Andrew. *Castle at War: The Story of a Siege (Discoveries Series).* New York: DK Publishing, Inc., 1998.
Learn how castles developed, who lived inside, how a medieval fortress was stormed, and how its defenses worked during a siege.

Platt, Richard. *Castle Diary: The Journal of Tobias Burgess, Page.* Cambridge, Massachusetts: Candlewick Press, 1999.
Eleven-year-old Tobias is a page in his uncle's castle. Set in thirteenth-century England, this book details castle and village life.

visit

www.learner.org/exhibits/middleages
Take a "reality tour" of the Middle Ages as part of this Annenberg/CPB project.

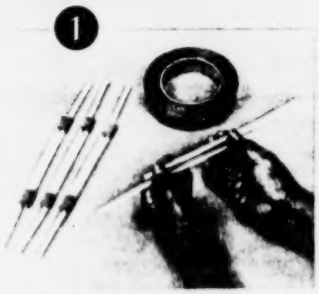
www.pbs.org/nova/lostempires/
Read about and view slides of medieval siege weapons and castles. Interactive activities let you launch a virtual model trebuchet.

Tabletop Trebuchet

King Edward has ordered you to build a new trebuchet. You will build the frame and throwing arm out of straws. You will use a paper clip for the axle and the toe of a stocking for the sling. Your missiles will be small balls of clay. But be forewarned—your trebuchet may take some trial and error, just as Warwolf did for its builders.

The NOVA team discovered that many different variables affected how well their trebuchets performed. Try isolating one variable at a time to explore how it changes your trebuchet's performance: size of missile, position of axle on throwing arm, or length of sling. What combination of adjustments gives you the greatest distance? What gives your missiles the greatest height? Can you think of other variables that affect your trebuchet's performance?

What to Do



First build the frame. Hold two straws with their jointed ends sticking out in opposite directions, as shown. Tape the straws together. Repeat three times so you have four pairs of straws.

Bend the ends of each pair of straws in opposite directions, as shown. Use a rubber band to connect two pairs together so the ends cross. This forms one side of the frame. Repeat with the other two pairs.

Straighten out the large paper clip to create an axle. Push it through the hole in the throwing arm. Next, bend up the joint on the short end of the throwing arm. Place the battery in the bend and tape it in place.

Cut off the toe of the stocking or sock to make a little boat-shaped sling. Cut a rubber band to form an open rubber string. Tie one end tightly to the corner of the sling.

What You Need

- **16 plastic straws with flexible joints**
- **tape**
- **3 small rubber bands**
- **safety pin**
- **1 large paper clip**
- **1 small paper clip**
- **a battery or other weight**
- **scissors**
- **an old nylon stocking or thin cotton sock**
- **modeling clay**
- **glasses or goggles to protect your eyes**

Be careful using the safety pin. You might want an adult to help with this step. Be sure to close the safety pin and put it away safely when you are done.

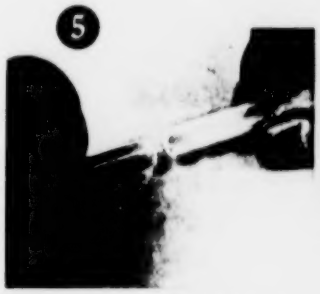
3

Tape the "feet" of the frame to a flat surface. (If it's not a surface you can put tape on, cover it with paper first.) The sides of the frame should be about 3.5 inches (9 centimeters) apart.

4

Add another straw as a brace behind each side of the frame. Tape the top of the brace to the frame.

5



Build a strong throwing arm by joining two straws together. Pinch the unjointed end of one straw and push it partway inside the end of another straw.

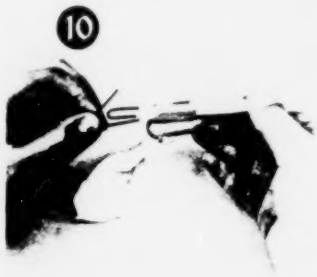
6

Use the safety pin to carefully poke a hole through the throwing arm where the two straws overlap. The hole should be closer to one end of the arm than the other, not exactly in the middle.

9

Tape the other end of the rubber string to the straw so that there is only a little rubber band showing between the end of the straw and the sling.

10



Next make a hook for the sling. Unbend one side of the small paper clip. Push the coiled part of the paper clip into the open end of the throwing arm. Adjust the free end of the paper clip to form a hook as shown.

11

Place the axle onto the top of your frame. The throwing arm should rest on the frame with the weighted end hanging down. Now you're ready to make some missiles of different sizes out of clay.

12

Tip the throwing end down, and load a missile into the sling. Hook the tip of the stocking gently over the paper clip. Now let go of the throwing arm and see what happens! You will probably need to make some adjustments to your trebuchet. See the box below for hints.

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Trebuchet Troubleshooting

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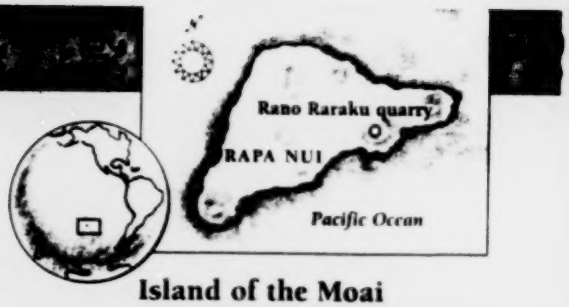
If the throwing arm doesn't rise high enough, try adding weight to the short end or moving your axle farther down toward the short end.
If the missile falls out of the sling too soon, try shortening the rubber band.
If the missile doesn't fall out of the sling, try adjusting the angle of the

Easter Island



Island of the Moai

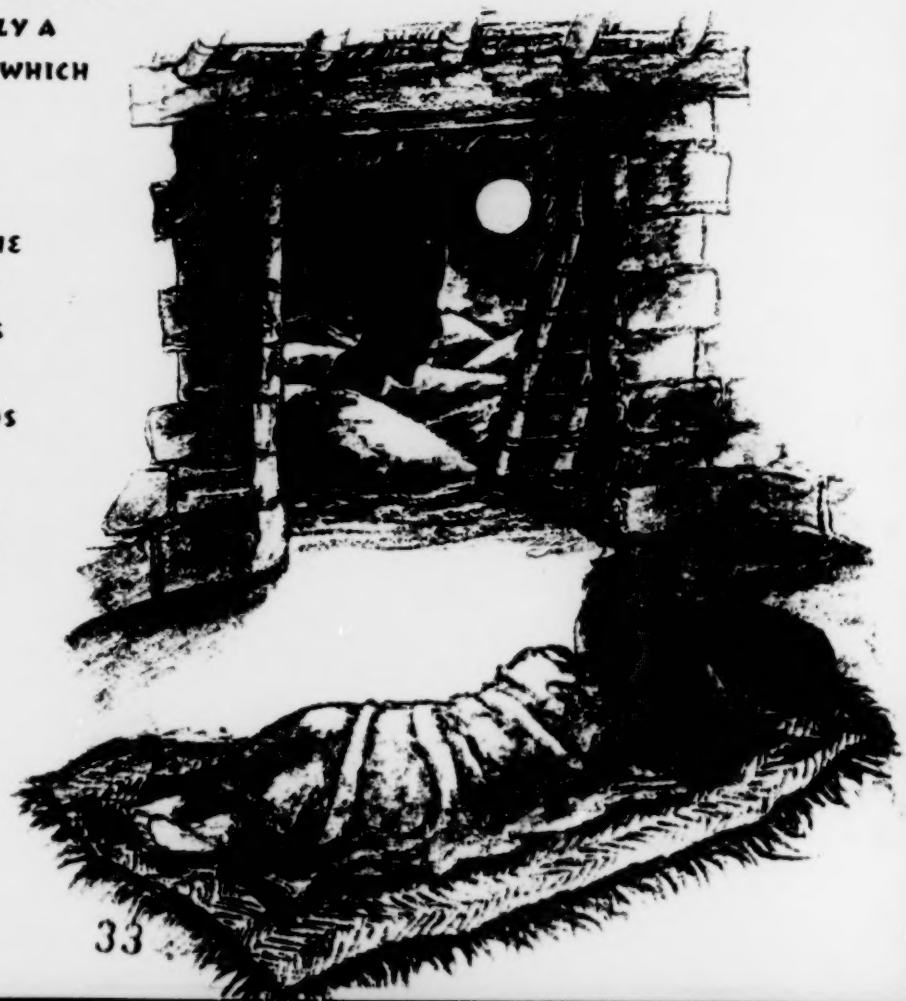
Rapa Nui is an island in the Pacific Ocean off the coast of Chile, 2,300 miles (3,700 kilometers) from the nearest populated area. The isolated island received another name from Admiral Jacob Roggeveen, who sailed a trade ship for the Dutch West India Company. He landed on the island on Easter Day, 1722, and called it "Easter Island" in honor of the holiday.

Most of the moai are thought to have been erected during the fourteenth and fifteenth centuries, when this story is set.

My name is Keke, and last night I dreamed the statues were walking.

I live on the island of Rapa Nui (rah´-pah noo´-ee). It is an empty place, with not many people. The island was formed from a volcano. The ground is very rocky. There is only a thin layer of soft dirt in which plants can grow.

But Rapa Nui has one thing that no other place in the world has. It has the moai (moh-eye´). The moai are the huge stone statues that are sacred to my people. There are hundreds of them all around our island. The moai stand on their pedestals, giant and silent, with their backs to the sea.



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I have lived with the moai all my life, so I am used to them. But last night I had a strange dream. I thought I was awakened by a strange sound on the path outside my house. It sounded like loud groaning.

I heard the noise again. Frightened, I sat up and looked outside through the open doorway of our house. Coming around a bend in the path, a huge shape stumbled forward slowly. I could not see its feet. Only the top of its head stuck up over a small hill between my house and the path.

The creature gave a huge groan, then swung one side of its body forward. Then it stopped as if gathering its strength. Giving another great cry, the creature shifted the other side of its body. Groan by groan, the creature staggered along. As it drew near, I saw its shape in the moonlight. It was one of the statues I had seen every day of my life.

And it was walking.

For a long time I lay shivering, terrified that the giant statue would turn from the path and head for our home. A moai weighs many tons, and could crush my family's small house in an instant. The next morning, I ran outside, but the statue was gone. It must have been a dream.

I told my mother about my dream as we ate our breakfast of sweet potatoes. She smiled and said I had dreamed about the power of our ancestors.

"Our people still carve the sacred moai out of the stones of the mountains. But at one time our people were not just excellent stone carvers. They possessed mana (mah'-nah), the power of the gods. Those with mana could command the moai to walk to their ahu. And the statues would walk."

The next night, the statue walked again. Again I thought I was awakened by the same horrible sound. It sounded like dozens of people all growling at once. Gruffff! Gruffff! But this time, I decided to go out and meet the moai.

THE MOAI often stand on ceremonial platforms called ahu (ah-hoo). Some of the statues, like those shown here, wear pukao (poo-kow) like headdresses or hats on their heads. The pukao are carved from a different kind of stone than the rest of the moai.

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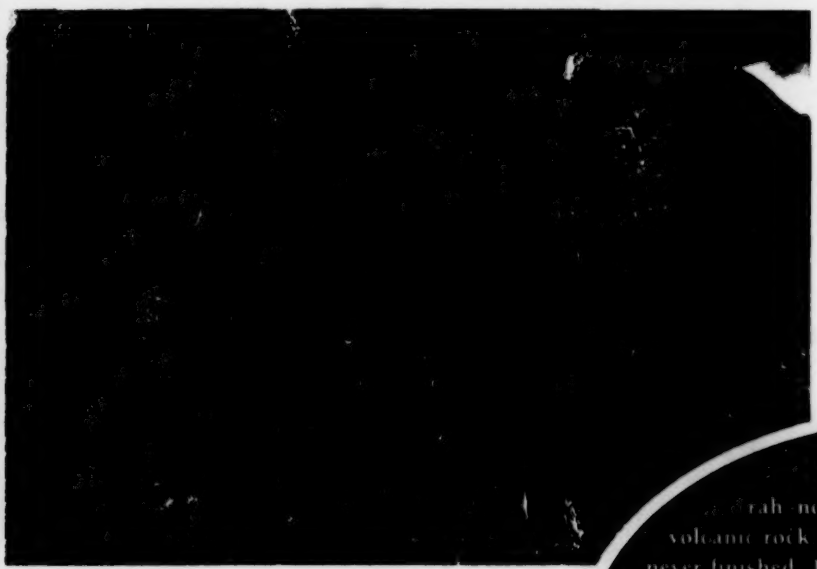
When I reached the path, I saw my mother, along with many other adults from our village. They were crowded around a huge moai with no eyes. It was lying on a wooden sled, and they were dragging it along the ground with ropes. Each time they pulled, the group let out a great shout of effort. That was the noise I had heard! I ran to my mother's side to ask what they were doing.

"We are bringing this moai to its ahu so that we may honor our ancestors and ask them to protect and help us," she said. "Unfortunately, our people no longer have mana. We must move the sacred statues in other ways. We have tried rocking the moai from side to side, like it is walking. But we feared it would fall. So now we are pulling it. It is difficult work, but our hardest task is still ahead. We must raise the moai so that it stands on its ahu. Only then can its eyes be opened."

So I had not been dreaming after all! I begged my mother to let me follow along. Now that I knew it was our people who made the statues move, I was more fascinated by the moai than ever.



Rano Raraku

(rah-noh rah-rah-koo) is a quarry of volcanic rock. It contains dozens of moai that were never finished. The Rapanui carved the moai with tools made of basalt, a stone that is harder than the volcanic rock from which the moai were formed. The moai were carved in the quarry, but the eye sockets were not opened until after each moai was standing on its ahu.

Find Out More

Arnold, Caroline. *Easter Island: Giant Statues Tell of a Rich and Tragic Past.* New York: Clarion Books, 2000.
This book describes the discovery of the moai statues, how they were built, and the myths surrounding them.

Orliac, Catherine, and Michael Orliac. *Easter Island: Mystery of the Stone Giants (Discoveries).* New York: Harry N. Abrams Inc., 1995.
Find out everything you want to know about Rapa Nui, including its moai and intriguing written language.

Routledge, Katherine. *The Mystery of Easter Island (Mystic Travellers Series).* Kempton, Illinois: Adventures Unlimited Press, 1998.
First published in 1919, this book was written by Englishwoman Katherine Routledge, who spent a year on Rapa Nui. She learned the islanders' language and interviewed them about their history.

www.escapeartist.com/easter/easter.htm
Visit the site for resources on Pacific studies, Easter Island's history, and visual overviews of the island and its moai.

www.pbs.org/nova/lostempires/
Read about Rapanui history and the many theories about the moai. Interactive activities let you explore the island and compare the size of the moai to other objects.

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Can You Move a Moai?

What to Do

No one knows for certain how the Rapanui raised the moai onto their ahu. The NOVA team used long wooden poles as levers. (To review how levers work, see page 8.) The moai was the load, a pile of stones was the fulcrum, and the team members applied the effort force to the poles. As the moai was slowly raised, other workers piled rocks in the space beneath the moai to hold it in its new position. In this way, little by little, the statue was lifted until it finally stood upright.

Now it's your turn to try raising a "moai."

Cut a strip of paper the same height as the can. Draw your moai on the paper (but don't draw the eyes yet).

Tape the moai to the can.

Roll some clay into a ball. Then flatten the clay to form your ahu. Place the moai face down next to the ahu.

Now try raising the moai. You may not touch the moai with your fingers. How can you use the pencils and books as levers and fulcrums to lift the moai onto the ahu? Once your moai is upright, you can "open its eyes."

When the NOVA team raised its moai, they had to overcome many challenges. For example, the pile of rocks beneath the rising moai was unstable. The ends of the levers became too high to reach. The team had to adjust their method as they went along. Try changing one thing about your method to find out whether it makes raising the moai easier or more difficult. For example, try changing the length of the lever or the position of the fulcrum.

What You Need

- an unopened soup can
- paper
- markers or crayons
- tape
- modeling clay
- 2 sharp pencils
- several books or blocks

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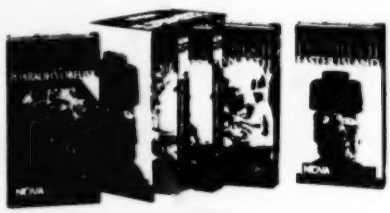

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Special thanks to
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Beth - talk to Karen Barnes re 4th possible budget request for pilot for Fin? We need to pursue Cynthia

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Major funding for NOVA is provided by

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Additional funding for *Secrets of Lost Empires* is provided by the David H. Koch Charitable Foundation, the Corporation for Public Broadcasting, and public television viewers.

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